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APPARATUS FOR MAKING METAL PELLETS

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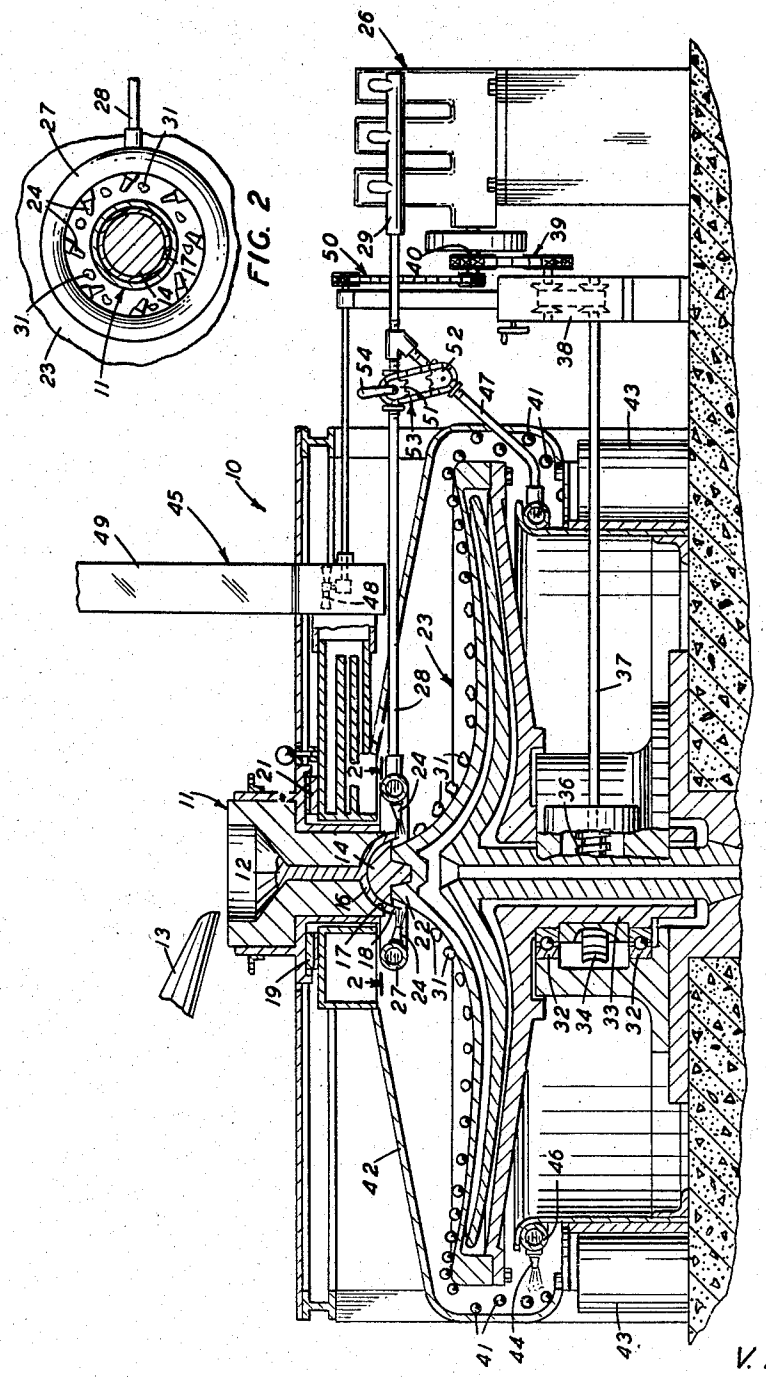


FIG. 1

FIG. 2

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APPARATUS FOR MAKING METAL PELLETS

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This invention relates to apparatus for making metal pellets, and more particularly to improved metal pelletizing apparatus of the type utilizing jets of nonoxidizing gases or vapors to break a freely falling stream of molten metal into a plurality of globules, which solidify to form metal pellets.

Apparatus for making substantially spherical metal pellets of the type utilizing a rotatable table for shaping and cooling globules of molten metal into spherical pellets is disclosed in V. A. Rayburn Patent 2,739,348, which issued on March 27, 1956. This apparatus utilizes jets of nonoxidizing gases or vapors obtained from an external source to break up an annular curtain of molten metal. The gases or vapors are passed through a flutter valve, which intermittently interrupts a steady stream of such gases or vapors to produce a pulsating stream. The pulsating stream is directed through nozzles onto the curtain of molten metal to break up the curtain of metal into globules of molten metal. As the globules of metal move downwardly and outwardly on a curved surface of a rotatable cooling table, the globules roll in a declining spiral path and are thereby shaped and cooled into substantially spherical pellets.

The patent also discloses that suitable nonoxidizing gases and vapors, supplied from an external source, are utilized to provide a protective atmosphere around the relatively hot globules of molten metal being shaped and cooled on the rotatable table. Further, the patent discloses that separate electrical motors, energized by an external source, are utilized to operate the flutter valve, to rotate the table and to drive a fan in an exhaust system to remove the vapors or gases from the apparatus.

It is desirable to have an apparatus for making substantially spherical metal pellets of the type described above, which is simpler in construction, more efficient to operate and will produce more uniform spherical metal pellets over a wider range of controllable sizes. It is also desirable to have pelletizing apparatus which is capable of operating as a unit substantially independent of and remote from external sources of power and external supply sources of gases or vapors utilized for preventing excessive oxidation of the molten and for breaking up a stream or curtain of molten metal into globules of molten metal.

An object of the present invention is to provide new and improved apparatus for making metal pellets.

Another object of the invention is to provide an improved metal pelletizing apparatus of the type utilizing jets of nonoxidizing gases or vapors to break a freely falling stream of molten metal into a plurality of globules, which solidify to form metal pellets.

Still another object of the invention is to provide new and improved apparatus for making substantially spherical pellets wherein a reciprocating piston internal-combustion engine is utilized for producing a pulsating stream of nonoxidizing gases, a protective atmosphere and the mechanical energy necessary for the operation of the apparatus.

An apparatus illustrating certain features of the invention may include a reciprocating piston internal-combustion engine producing an exhaust of pulsating, substantially nonoxidizing gases, and means for directing a flow of the pulsating exhaust gases against a stream of molten metal to break up the stream into a plurality of molten metal globules which solidify into pellets.

Other objects and features of the invention will be more readily understood from the following detailed description, when read in conjunction with the accompanying drawings, in which:

Fig. 1 is a fragmentary elevation of apparatus for making metal pellets embodying certain principles of the present invention, with portions broken away for purposes of clarity, and

Fig. 2 is a fragmentary, horizontal section of the apparatus of Fig. 1 taken along line 2—2 thereof.

Referring now to the drawings, and more particularly to Fig. 1 thereof, there is shown an apparatus, designated generally by the numeral 10, for making substantially spherically shaped metal pellets. The apparatus is of the same general construction and operated in a manner similar to that disclosed in the above-mentioned patent.

The apparatus 10 includes a standpipe, designated generally by the numeral 11, in which molten metal 12, such as copper, is introduced by a pouring spout 13. Positioned beneath the standpipe 11 is a dome-shaped spill head 14, the upper surface of which matches a concave recess 16 in the lower portion of the standpipe 11. The molten metal 12 flows from the standpipe 11 through a restricted passage 17 of a variable size formed between the wall of the recess 16 and the dome-shaped top of the spill head 14. The contour of the passage 17 and rotary motion of the spill head 14 with respect to the concave recess 16 cause the molten metal to flow off the dome-shaped top of the spill head in the form of a thin-walled, annular curtain 18.

The thickness of the annular curtain 18 depends upon the size of the passage 17 which may be adjusted by turning the standpipe 11 about its vertical axis so that a downwardly projecting camming surface of an annular cam 19, secured fixedly thereto, is rotated with respect to a contiguous upwardly projecting camming surface of a stationary annular cam 21. The spill head 14 is secured fixedly to a raised central portion 22 of a rotatable, circular, cooling table, designated generally by the numeral 23, and is rotated by the table with respect to the standpipe 11, which remains relatively stationary.

A plurality of nozzles 24—24 are located adjacent to the position where the molten metal curtain 18 falls off the edge of the spill head 14 and are spaced circumferentially therearound. A stream of pulsating, nonoxidizing exhaust gases from a reciprocating piston internal-combustion engine, preferably from a four-cycle, three-cylinder gasoline engine, designated generally by the numeral 26, is supplied to a header 27, on which the nozzles 24—24 are mounted, by means of an exhaust pipe 28, connected to an exhaust manifold 29 of the engine 26. The rate of pulsations of the exhaust gases may be controlled over a relatively wide range by simply changing the speed of the engine 26 by conventional throttling means (not shown).

Pulsating jets of exhaust gases emerging from the nozzles 24—24 impinge upon and break up the annular curtain 18 of molten metal 12 falling downwardly around the spill head 14. The pulsating jets of exhaust gases break the curtain 18 of the molten metal 12 into a plurality of globules or droplets 31—31 which fall upon the raised central portion 22 of the rotatable table 23.

The table 23 is mounted rotatably on a pair of radial thrust bearings 32—32 by a hollow central shaft 33 through which a cooling fluid for the table, such as water, is circulated by appropriate means (not shown). A ring

gear 34 is secured fixedly around the hollow shaft 33 and is engaged by a worm gear 36 keyed to and rotated by a shaft 37. The shaft 37 is connected to a positively, infinitely variable transmission unit 38 driven by means of a chain and sprocket arrangement, designated generally by the numeral 39, from an output shaft 40 of the engine 26. When the curtain 18 of the molten metal is broken into a plurality of molten metal globules 31—31 by the pulsating jets of exhaust gases emerging from the nozzles 24—24, the globules fall upon a raised central portion 22 of the table 23 and begin to roll down the incline toward a substantially horizontal portion of the table, where they solidify into pellets 41—41.

To insure that the pellets 41—41 are of a substantially spherical form, the table 23 should be rotated at such speeds that after the globules 31—31 strike the central portion 22 of the table 23 and begin to roll radially downwardly and outwardly they will also roll generally circumferentially with respect to the table and will then assume a rolling motion about an infinite number of axes thereof due to rotation of the table. The globules 31—31 of molten metal then flow downwardly and outwardly over the surface of the table in the form of constantly expanding spirals toward the outer periphery of the table and are discharged therefrom. The pellets 41—41 thrown from the periphery of the table 23 strike the inner wall of a hood 42 and fall into cylindrical drums 43—43 positioned therebelow.

The speed of rotation of the table 23 is preferably maintained at such a rate as to prevent undue crowding of the globules 31—31 to eliminate the possibility of coalescense of the globules while being shaped and cooled to form pellets 41—41, and to prevent the pellets from being thrown off the table prematurely. The speed of rotation of the table 23 may be adjusted by means of the transmission unit 38 irrespective of the speed of the operation of the engine 26.

The temperature of the cooling fluid should also be controlled, since if the globules are cooled too quickly they might solidify before attaining a substantially spherical form, and if the globules are cooled too slowly they might coalesce while still on the table or in the drums, or might be deformed when they hit the hood 42 while being thrown off the table 23 or when they fall into the drums 43—43.

The hood 42 is also used to confine gases, fumes and vapors (i.e. exhaust gases emitted by the nozzles 24—24 together with any fumes and vapors arising from the molten metal 12). Since these gases, fumes and vapors will be confined mostly to the upper part of the apparatus 10, the relatively hot globules 31—31 and warm pellets 41—41 on the table 23, and being thrown therefrom, would probably oxidize rapidly, if ambient air from outside of the apparatus 10 were permitted to enter the hood 42.

The space under the hood is filled with substantially nonoxidizing exhaust gases from the engine 26 by means of outlets, only one of which designated 44 is shown, arranged circumferentially and projecting from an annular manifold 46. The exhaust manifold 29 of the engine 26 is connected to the manifold 46 by pipe 47. The exhaust gases of the engine 26 emerging from the outlets 44—44 into the space under the hood 42, together with exhaust gas emitted by the nozzles 24—24 and any fumes and vapors arising from the molten metal, exclude air from the space underneath the hood, to such concentration as to render the atmosphere under the hood substantially nonoxidizing, thereby providing a protective atmosphere around the relatively hot globules 31—31 and the warm pellets 41—41.

An exhaust system, designated generally by the numeral 45, is provided to minimize the escape of gases, fumes and vapors from under the hood 42. An exhaust fan 48 in the exhaust system 45 is provided to induce the gases from the hood into a suitable discharge stack 49.

Since, when the rate of operation of the engine 26 is varied, the amount of exhaust gas produced thereby and supplied under the hood 42 is also varied, it is necessary to vary the suction of the exhaust fan 48 accordingly. It is possible to correlate the variations in suction of the exhaust fan with the variations in the rate of operation of the engine 26 by operating the exhaust fan 48 from the output shaft 40 of the engine 26 by means of a chain and sprocket drive, designated generally by the numeral 50.

By varying the thickness of the curtain of the molten metal, the rate of pulsations and the pressure of the pulsating jets of the exhaust gases emerging from the nozzles 24—24, the speed of rotation of the table 23, and the flow of the cooling fluid, it is possible to control the range of sizes of the pellets produced by the apparatus 10. Further, by varying one or all of these factors it is possible to control the size and shape of the pellets within each desired size range.

For example, by varying the thickness of the curtain 18 of the molten metal, it is possible to increase or decrease the average size of the pellets depending on whether the thickness of the curtain is increased or decreased, respectively. Similarly, by varying the rate of pulsations, it is possible to increase or decrease the average size of the pellets depending on whether the rate of pulsations is decreased or increased, respectively. By varying the pressure of the pulsating jets of the exhaust gases impinging upon the curtain 18 of the molten metal 12, the sizes of metal pellets may also be varied within certain limits.

To insure that the pulsations of the gases emitting from the nozzles 24—24 are as sharp as practical, the engine 26 should be located so that the exhaust gases from the cylinders of the engine will follow the shortest and straightest path to the nozzles, which is practical under the circumstances. Also, the size of the exhaust pipe 28 should be such as to permit the transmission of sharp pulsations of the exhaust gases without appreciable dampening. If the cross section of the exhaust pipe 28 is too large, the pulsations of the exhaust gases will tend to be dampened out. On the other hand, if the cross section of the exhaust pipe 28 is too small, the pulsations of the exhaust gases will tend to be dampened or cushioned, due to the resistance of the walls of the pipe to the flow of gases therein. For certain lengths of the exhaust pipe 28 the best suitable size of the exhaust pipe to provide for as sharp pulsations of the exhaust gas as practical for a given engine may be determined experimentally. For example, the cross-sectional area of the pipe 28 may be in a range of from ⅓ to ⅔ the area of a cylinder head of the engine depending upon the length of the exhaust pipe in ranges from 100 to 200 diameters thereof.

The flow of the exhaust gases emerging from the nozzles 24—24 may be regulated by means of a butterfly valve 51 connected in the exhaust pipe 28 and a butterfly valve 52 connected in the pipe 47. A chain and sprocket pair, designated generally by the numeral 53, is connected to the valves 51 and 52 so that both valves can be adjusted by turning a single handle 54 on the butterfly valve 51. Since all of the exhaust gases of the engine 26 are directed into the hood 42 through the nozzles 24—24 and outlets 44, the setting of the butterfly valves 51 and 52 are such that when one valve is fully open the other is fully closed. Therefore, when the handle 54 is moved to change the amount of exhaust gases passing through the valve 51, the remaining portion of the exhaust gases produced by engine 26 is directed through the valve 52.

The use of a reciprocating piston engine 26, such as a gasoline or diesel internal-combustion engine, offers great flexibility, more economical operation and a number of other advantages over the apparatus disclosed in the above-mentioned patent. The engine 26 produces sharply pronounced pulsations of exhaust gases which are directed to and emitted by the nozzles 24—24,

thereby eliminating the necessity for maintaining an external, independent supply of steam, vapors or gases and a separate means for causing pulsations in the steam, vapors or gases, such as a flutter valve. The exhaust gases produced by the engine **26** are of a substantially nonoxidizing nature and consist essentially of carbon dioxide, carbon monoxide, water vapor, and traces of unburned gasoline or diesel oil vapors. Traces of unburned gasoline or diesel oil vapors, that inadvertently come into the hood with the exhaust gases, can be burned by combining with traces of oxygen allowed to enter from around the outside of the hood.

In case the engine **26** is cooled by means of a water cooling system (not shown) the apparatus **10** may be made more substantially self-sufficient by utilizing this cooling system also for cooling the table **23**. In such a case, the cooling water for cooling the table **23** and the engine **26** may be circulated by a single water pump (not shown) associated with and driven by the engine **26**.

It will be obvious that various changes and modifications may be made therein without departing from the spirit and scope of the invention. While the apparatus has been described as being suitable for the manufacture of copper shot or pellets, pellets or shot of other metals, such as iron, lead, zinc, and the like, may be made by means of apparatus of this same general design.

What is claimed is:

1. Apparatus for making metal pellets from a freely falling stream of molten metal, which comprises a reciprocating piston internal-combustion engine producing an exhaust of pulsating substantially nonoxidizing gases, and means for directing a flow of said pulsating gases against a freely falling stream of molten metal to break the stream into a plurality of globules of the molten metal, which solidify to form metal pellets.

2. Apparatus for making metal pellets from a freely falling stream of molten metal, which comprises a reciprocating piston internal-combustion engine producing an exhaust of pulsating substantially nonoxidizing gases, and means for converting said pulsating gases into a plurality of relatively high velocity pulsating jets and for directing said pulsating jets against the freely falling stream of molten metal to break the stream into a plurality of globules of the molten metal, which solidify to form metal pellets.

3. Apparatus for making metal pellets from a freely falling stream of molten metal, which comprises a reciprocating piston internal-combustion engine producing an exhaust of pulsating substantially nonoxidizing gases, means for converting said pulsating gases into a plurality of relatively high velocity pulsating jets and for directing said pulsating jets against the freely falling stream of molten metal to break the stream into a plurality of globules of the molten metal, which solidify to form metal pellets, and means for varying the volumetric rate of flow of the molten metal in the stream to vary the average size of the pellets produced by said apparatus.

4. In apparatus for making metal pellets including means for producing a curtain of a freely falling stream of molten metal, a plurality of nozzles for directing gases at relatively high velocities against said curtain of molten metal, and a rotatable table toward which the stream of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine producing an exhaust of substantially nonoxidizing pulsating gases, and means for conducting at least a portion of said exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon the stream of molten metal and break the stream into a plurality of molten metal globules.

5. In apparatus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against the freely falling curtain of molten metal, and a rotatable table toward which the curtain of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine having an exhaust of substantially nonoxidizing pulsating gases, first means for conducting a first portion of the exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon said curtain of molten metal and break the curtain into a plurality of molten metal globules, and second means for conducting a second portion of the exhaust gases into surrounding relationship with the table to form a protective nonoxidizing atmosphere thereabout.

6. In apparatus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against the freely falling curtain of molten metal, and a rotatable table toward which the curtain of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine having an exhaust of substantially nonoxidizing pulsating gases, first means for conducting a first portion of the exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon the curtain of molten metal and break the curtain into a plurality of molten metal globules, second means for conducting a second portion of the exhaust gases into surrounding relationship with the table to form a protective nonoxidizing atmosphere thereabout, and valve means for controlling the flow of the exhaust gases through said first and said second conducting means in any desired ratio of portions of the total exhaust gases of the engine.

7. In appaartus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against said curtain of molten metal, and a rotatable table toward which the curtain of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine producing an exhaust of substantially nonoxidizing pulsating gases, means for conducting at least a portion of said exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon the curtain of molten metal and break the curtain into a plurality of molten metal globules, and means for adjusting the rotational speed of the table independently of the speed of the engine.

8. In apparatus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against said curtain of molten metal, and a rotatable table toward which the curtain of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine producing an exhaust of substantially nonoxidizing pulsating gases, and means for conducting at least a portion of said exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon said curtain of molten metal and break the curtain into a plurality of molten metal globules, said engine also having means for adjusting the speed thereof to control the rate of pulsation of the gases in the jets.

9. In apparatus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against the freely falling curtain of molten metal, a rotatable table toward which the curtain of molten metal is falling, the improvement which com-

prises a reciprocating piston internal-combustion engine connected operatively to said table for rotation thereof, said engine having an exhaust of substantially nonoxidizing pulsating gases, first means for conducting a first portion of the exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon said curtain of molten metal and break the curtain into a plurality of molten metal globules, second means for conducting a second portion of the exhaust gases into surrounding relationship with the table to form a protective nonoxidizing atmosphere thereabout, and means for exhausting said exhaust gases from the apparatus for preventing contamination of space immediately surrounding said apparatus with said exhaust gases, said exhaust means including a rotatable impeller connected operatively to said engine for rotation thereby.

10. In apparatus for making metal pellets including means for producing a freely falling curtain of molten metal, a plurality of nozzles for directing gases at relatively high velocities against the freely falling curtain of molten metal, and a rotatable table toward which the curtain of molten metal is falling, the improvement which comprises a reciprocating piston internal-combustion engine connected operatively to said table for rotation

thereof, said engine having an exhaust of substantially nonoxidizing pulsating gases, first means for conducting a first portion of the exhaust gases to said nozzles whereby relatively high velocity jets of pulsating gases impinge upon the curtain of molten metal and break the curtain into a plurality of molten metal globules, second means for conducting a second portion of the exhaust gases into surrounding relationship with the table to form a protective nonoxidizing atmosphere thereabout, valve means for controlling the flow of the exhaust gases through said first and second conducting means in any desired ratio of portions of the total exhaust gases of the engine, and means for adjusting the rotational speed of the table independently of the speed of the engine, said engine also having means for adjusting the speed thereof to control the rate of pulsation of the gases in the jets.

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